WHAT IS CLAIMED IS:

1.   1.   A method of scheduling a media object for transmission between a
2. server and a client, the method comprising:
3.   partitioning the media object into segments of blocks, wherein each block is a
4. unit of media for which the client will wait to receive an entire block before playing out the
5. block, and wherein each segment includes an integer number of blocks;
6.   determining one or more channels on which to serve each segment, the
7. channels capable of carrying data between the server and the client;
8.   determining a rate at which to serve each segment; and
9.   determining a schedule pair for each channel, the schedule pair including a
10. time at which the client may start receiving on the channel and a time at which the client may
11. stop receiving on the channel.

1.   2.   The method of claim 1 wherein if the client minimally fulfills the
2. schedule pair for each channel, the client will be able to play out the media object
3. uninterrupted after a startup latency.

1.   3.   The method of claim 1 wherein the partitioning step includes first
2. partitioning the media object into segments, then partitioning each segment into an integer
3. number of blocks.

1.   4.   The method of claim 1 wherein the partitioning step includes first
2. partitioning the media object into blocks, then grouping the blocks into segments.

1.   5.   The method of claim 1 wherein a maximum download rate at the client
2. is less than an aggregate server transmission rate.

1.   6.   The method of claim 1 wherein a maximum download rate at the client
2. is unconstrained.

1.   7.   The method of claim 1 wherein a maximum download rate at the client
2. is only slightly greater than a media object play out rate.

1.   8.   The method of claim 1 wherein a maximum download rate at the client
2. is less than a media object play out rate.

1   9.   The method of claim 1 wherein at least one segment includes more

2   than one block.

1   10.   The method of claim 1 wherein each segment includes exactly one

2   block.

1   11.   The method of claim 1 wherein a plurality of blocks in a segment are a

2   same size.

1   12.   The method of claim 1 wherein a plurality of blocks in a plurality of

2   segments are a same size.

1   13.   The method of claim 1 wherein at least two of the channels are served

2   at different rates.

1   14.   The method of claim 1 wherein at least two segments have different

2   sizes.

1   15.   The method of claim 1 wherein each block in each segment is served at

2   a same rate.

1   16.   The method of claim 1 wherein at least one block in at least one

2   segment is served at a rate different than other blocks in the segment.

1   17.   The method of claim 1 wherein the segments are served at a rate less

2   than a play out rate.

1   18.   The method of claim 1 wherein at least one segment is served on at

2   least two channels, and wherein each of the at least two channels is served at a rate.

1   19.   The method of claim 18 wherein the each of the at least two channels

2   are served at a same rate.

1   20.   The method of claim 18 wherein at least two of the each of the at least

2   two channels are served at different rates.

1   21.   The method of claim 1 wherein the number of channels is less than or

2   equal to a maximum number of concurrent channels at the client.

1   22.   The method of claim 2 wherein the client can minimally fulfill the

2   schedule pair for each channel by downloading from a maximum number of concurrent

3   channels.

1   23.   The method of claim 1 wherein the number of channels is less than or

2   equal to a maximum number of concurrent channels served by the server.

1   24.   The method of claim 1 wherein the partitioning, determining one or

2   more channels, determining a rate, and determining a schedule pair steps are performed so as

3   to optimize a server bandwidth required to serve the media object.

1   25.   The method of claim 1 wherein the partitioning, determining one or

2   more channels, determining a rate, and determining a schedule pair steps are performed so

3   that the media object is served to the client at a rate less than or equal to a maximum client

4   download rate.

1   26.   The method of claim 1 further comprising, for each of the plurality of

2   segments, determining a size of the segment so that the segment is completely downloaded

3   by the client prior to when the segment is due to be played out.

1   27.   The method of claim 26 wherein, for each of the plurality of segments,

2   the rate at which to serve the segment is an integer multiple of a base rate.

1   28.   The method of claim 26 wherein all of the segments are served at a

2   same rate.

1   29.   The method of claim 1 further comprising, for each of a plurality of

2   segments:

3   if the segment may be scheduled to be served to the client without exceeding a

4   maximum client download rate, scheduling the segment to be served to the client; and

5   if the segment may not be scheduled to be served to the client without

6   exceeding the maximum client download rate, waiting to schedule the segment to be served

7   until one or more other segments are scheduled to end being downloaded at the client.

1   30.   The method of claim 1 wherein the partitioning, determining one or

2   more channels, determining a rate, and determining a schedule pair steps are performed so as

3   to optimize a number of concurrent channels at the server required to serve the media object.

1   31.   The method of claim 1 wherein sizes of a plurality of blocks are each

2   less than or equal to a maximum block size.

1   32.   The method of claim 1 wherein sizes of a plurality of segments are

2   each less than or equal to a maximum segment size.

1   33.   The method of claim 32 wherein the maximum segment size is based

2   on a maximum available storage at the client.

1   34.   The method of claim 1 wherein sizes of a plurality of blocks are each

2   greater than or equal to a minimum block size.

1   35.   The method of claim 34 wherein the minimum block size is

2   determined by an encoding scheme.

1   36.   The method of claim 34 wherein the minimum block size is

2   determined by a media object player data format.

1   37.   The method of claim 1 wherein the partitioning step includes, for each

2   of a plurality of segments, determining a start point of the segment and an end point of the

3   segment based upon requirements of a media object player data format.

1   38.   The method of claim 1 wherein the partitioning step includes, for each

2   of a plurality of blocks, determining a start point of the block and an end point of the block

3   based upon requirements of a media object player data format.

1   39.   The method of claim 1 wherein the rate and the schedule pair are based

2   on a maximum available storage at the client.

1   40.   The method of claim 1 wherein the rate varies over time.

1   41.   The method of claim 1 wherein at least one segment is served on at

2   least two channels, and wherein a rate at which the segment is served on one of the at least

3   two channels varies over time.

1　　　　42.　The method of claim 1 wherein a set of channels serving at least one

2　segment varies over time.

1　　　　43.　A system for scheduling a media object for transmission between a

2　server and a client, comprising:

3　　　　　a module for partitioning the media object into segments of blocks, wherein

4　each block is a unit of media for which the client will wait to receive an entire block before

5　playing out the block, and wherein each segment includes an integer number of blocks;

6　　　　　a module for determining one or more channels on which to serve each

7　segment, the channels capable of carrying data between the server and the client;

8　　　　　a module for determining a rate at which to serve each segment; and

9　　　　　a module for determining a schedule pair for each channel, the schedule pair

10　including a time at which the client may start receiving on the channel and a time at which

11　the client may stop receiving on the channel.

1　　　　44.　A method of serving a media object, the method comprising:

2　　　　　receiving segments of a media object, wherein each segment includes an

3　integer number of blocks, wherein each block is a unit of media for which a client will wait to

4　receive an entire block before playing out the block, and wherein each block includes one or

5　more input symbols;

6　　　　　for each segment, receiving an indication of one or more channels on which to

7　serve the segment;

8　　　　　for each segment, receiving a rate at which to serve the segment;

9　　　　　determining an order in which to encode blocks;

10　　　　　generating output symbols for each block in the order; and

11　　　　　transmitting the output symbols on the corresponding one or more channels,

12　wherein each segment is served at the corresponding rate.

1　　　　45.　The method of claim 44 further comprising providing one or more

2　storage devices on which to store the media object.

1　　　　46.　The method of claim 44 wherein the receiving a rate step includes

2　receiving an aggregate rate at which to serve the segment on the one or more channels.

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1   47.   The method of claim 44 wherein the receiving a rate step includes, for
2   each of the one or more channels on which to serve the segment, receiving a rate at which to
3   serve the segment on the each of the one or more channels.

1   48.   The method of claim 44 wherein a server serves at least two media
2   objects concurrently.

1   49.   The method of claim 44 wherein a media object is concurrently served
2   on at least two servers.

1   50.   The method of claim 49 wherein at least one segment is concurrently
2   served on at least two servers.

1   51.   The method of claim 49 wherein at least one segment is served on only
2   one server.

1   52.   The method of claim 44 wherein the media object is served on unicast
2   channels.

1   53.   The method of claim 44 wherein the media object is served on
2   multicast channels.

1   54.   The method of claim 44 wherein the media object is served on
2   broadcast channels.

1   55.   The method of claim 44 wherein generating output symbols includes
2   using a chain reaction code to generate output symbols.

1   56.   The method of claim 44 wherein generating output symbols includes
2   using a FEC code to generate output symbols.

1   57.   The method of claim 56 wherein all of the output symbols in a block
2   are generated before transmitting any of the output symbols in the block.

1   58.   The method of claim 56 wherein for some or all of the plurality of
2   output symbols, each of the some or all of the output symbols is generated upon a first
3   transmission of the output symbol on the channel.

1   59.   The method of claim 56, further including determining an order in

2   which to transmit output symbols corresponding to a block, and wherein transmitting output

3   symbols includes transmitting output symbols corresponding to a block in the order.

1   60.   The method of claim 59 wherein the order is determined according to a

2   random or pseudo-random sequence.

1   61.   The method of claim 44, further including determining an order in

2   which to transmit output symbols for each block in a segment, and wherein transmitting

3   output symbols includes, for each segment, transmitting output symbols corresponding to

4   each block in the order.

1   62.   The method of claim 61 wherein the order is determined according to a

2   random or pseudo-random sequence.

1   63.   The method of claim 44 wherein input symbols are used as output

2   symbols.

1   64.   The method of claim 44 wherein a server transitions between serving a

2   first media object and a second media object by successively stopping the serving of

3   segments for the first media object and successively starting the serving of segments for the

4   second media object.

1   65.   The method of claim 44 wherein the rate at least one segment is served

2   on a channel varies over time.

1   66.   The method of claim 44 wherein at least one segment is served on at

2   least two channels.

1   67.   The method of claim 44 wherein, for at least one segment, the one or

2   more channels on which the segment is served varies over time.

1   68.   An apparatus for serving a media object, comprising:

2   a block encoder coupled to receive segments of a media object, wherein each

3   segment includes an integer number of blocks, wherein each block is a unit of media for

4   which a client will wait to receive an entire block before playing out the block, wherein each

5   block includes one or more input symbols; the block encoder including an input to receive an

6   order in which to encode the blocks; and wherein the block encoder is configured to generate,

7   in the order, output symbols for each block; and

8   a transmitter coupled to receive the output symbols from the block encoder,

9   and coupled to receive, for each segment, an indication of one or more channels on which to

10   serve the segment and a rate at which to serve the segment;

11   said transmitter configured to serve the output symbols on the corresponding

12   one or more channels at the corresponding rate.

1   69.   A method of receiving a media object that includes segments of blocks,

2   wherein each segment includes an integer number of blocks, and wherein each block is a unit

3   of media for which a client will wait to receive an entire block before playing out the block,

4   the method comprising:

5   receiving a media object description of the media object;

6   joining and leaving each of a plurality of channels according to the media

7   object description to download the segments;

8   reassembling the blocks in each segment; and

9   playing the blocks out in an order after a startup latency.

1   70.   The method of claim 69 wherein a client joins channels according to an

2   order in the media object description.

1   71.   The method of claim 69 wherein, reassembling the blocks of a first

2   segment and playing out the blocks of a second segment occur concurrently.

1   72.   The method of claim 69 wherein segments are downloaded on unicast

2   channels.

1   73.   The method of claim 69 wherein segments are downloaded on

2   multicast channels.

1   74.   The method of claim 69 wherein segments are downloaded on

2   broadcast channels.

1   75.   The method of claim 69 wherein a plurality of segments are

2   downloaded concurrently at an aggregate rate, and wherein the aggregate rate is less than a

3   maximum download rate.

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1   76.   The method of claim 69 wherein the media object is downloaded by a
2   client at a rate less than an aggregate server transmission rate.

1   77.   The method of claim 69 wherein the media object is downloaded by a
2   client at an unconstrained rate.

1   78.   The method of claim 69 wherein the media object is downloaded by a
2   client at a rate only slightly greater than a media object play out rate.

1   79.   The method of claim 69 wherein the media object is downloaded by a
2   client at a rate less than a media object play out rate.

1   80.   The method of claim 69 wherein joining and leaving a plurality of
2   channels includes downloading at least a first segment upon the ending of the downloading of
3   a second segment.

1   81.   The method of claim 69 wherein a rate at which the media object is
2   downloaded may be adjusted by joining and leaving channels.

1   82.   The method of claim 81 wherein a client increases its reception rate by
2   adding channels according to an order and decreases its reception rate by dropping channels
3   either in a reverse of the order, or when a segment completes downloading on that channel.

1   83.   The method of claim 81 wherein a client increases its reception rate
2   when it experiences no congestion and decreases its reception rate when it experiences
3   congestion.

1   84.   The method of claim 69 wherein the blocks include original data, and
2   wherein reassembling the blocks in each segment includes reordering the original data
3   according to its temporal position in each block.

1   85.   The method of claim 69 wherein reassembling the blocks in each
2   segment includes decoding with a FEC decoder.

1   86.   The method of claim 69 wherein reassembling the blocks in each
2   segment includes decoding with a chain reaction decoder..

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1   87. The method of claim 69 wherein a single media object is downloaded

2 from at least two servers.

1   88. The method of claim 87 wherein at least one segment is downloaded

2 from at least two servers.

1   89. The method of claim 87 wherein at least one segment is downloaded

2 from only one server.

1   90. The method of claim 69 wherein a same segment in the media object is

2 downloaded from at least two servers.

1   91. The method of claim 69 further comprising playing out a pre-

2 downloaded segment during the startup latency.

1   92. The method of claim 69 wherein the media object is downloaded by a

2 client from a maximum number of channels concurrently.

1   93. The method of claim 69 wherein a set of channels on which at least

2 one segment is downloaded varies over time.

1   94. A system for receiving a media object that includes segments of

2 blocks, wherein each segment includes an integer number of blocks, and wherein each block

3 is a unit of media for which a client will wait to receive an entire block before playing out the

4 block, comprising:

5   a module for handling input of a media object description of the media object;

6   a module for handling channel joins and channel leaves for each of a plurality

7 of channels according to the media object description, wherein the channels are capable of

8 use for downloading the segments to the client;

9   a module for reassembling the blocks in each segment; and

10   a module for playing the blocks out in an order after a startup latency.